C. COMMERCIAL LAUNCH VEHICLE INFORMATION AND DESCRIPTION - The characteristics of launch vehicles are as follows:

1. The Scout Launch Vehicle

a. Description - The normal configuration of the Scout launch vehicle is a four-stage, solid propellant vehicle which is made up of the Algol III-A first-stage motor, the Castor II-A second-stage motor, the Antares III-A third-stage motor and the Altair III-A fourth-stage motor. It is 3.7 feet in diameter, is approximately 75 feet tall and weighs 47,200 pounds at lift-off. It develops 107,000 pounds of thrust at lift-off and is capable of placing 400 pound payloads into a 345 statute mile orbit.[11] See **Figure 10**[8] for a typical Scout vehicle.

b. Hazards - The primary hazards of this launch vehicle during preparation and launch are scattered pieces of burning propellant resulting from a pressure rupture of the separate stages and any toxic propellants that may be associated with the spacecraft; i.e., Hydrazine (N_2H_4).[12] WFF provides the special suits, breathing apparatus, leak detection equipment and laboratory quality analysis support required for handling the hydrazine. Detailed procedures for fueling the propellant servicing unit and the spacecraft have been established and approved by the appropriate safety organizations and documented in the Ground Safety Plan.[13] After lift-off, the additional hazards of impacting stages and missile parts as well as possible detonation of stages upon impact must be considered.

c. Trajectory - Except for special cases, the Scout is launched on azimuths of 90^0 to 109^0 and 126^0 to 129^0. It clears the Wallops Island land mass in approximately 5 seconds. Launch in the corridor of 109^0 to 126^0 is not normally allowed due to the close proximity of Bermuda to the second stage impact point; however, exceptions have been made when Range Safety criteria could be satisfied.

d. In-Flight Events - The sequence of in-flight events for a typical mission is shown in **Table 4**.[8]

TABLE 4. SCOUT NOMINAL SEQUENCE OF EVENTS

EVENT	TIME (SEC)	EVENT	TIME (SEC)
LAUNCH	T+0	ST III IGNITION	T+199
ST I BURNOUT	T+85	ST II SEP	T+199
ST II IGNITION	T+88	ST III BURNOUT	T+246
ST I SEP	T+88	ST IV SPINUP	T+586
ST II BURNOUT	T+128	ST IV IGNITION	T+592
HS EJECT	T+197	ST IV BURNOUT	T+625

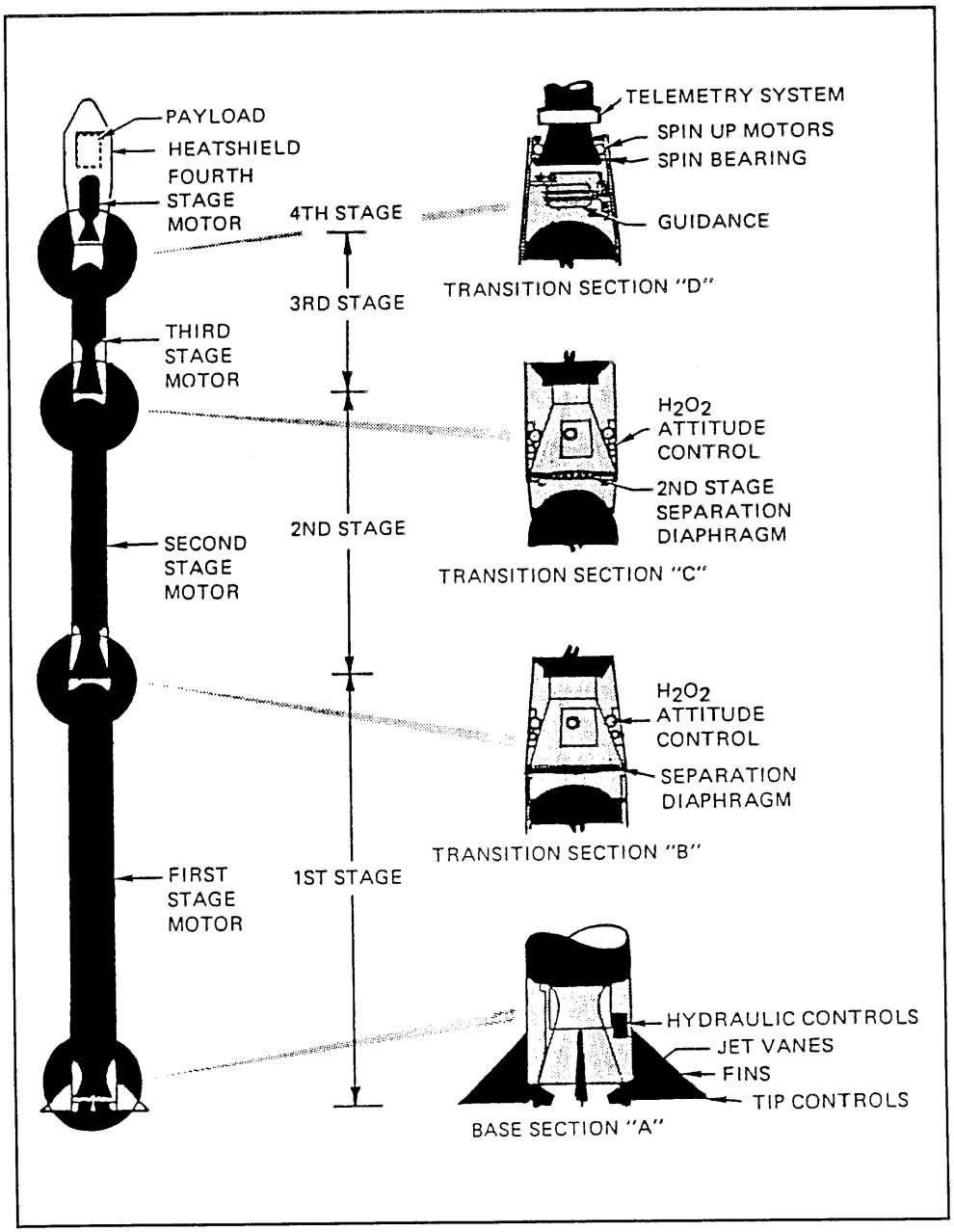

FIGURE 10. TYPICAL SCOUT VEHICLE

e. Airborne FTS - The FTS consists of two antenna pairs, two receivers and one Destruct Relay Unit mounted on the third stage, with Safe and Arm (S/A) devices and shaped charges on each of the first three stages. Inadvertent Separation Destruct Systems (ISDS) are located on the first and second stages. The fourth and fifth (if applicable) stages do not have destruct systems; however, if the destruct command is sent, the third stage shaped charges destroy the fourth stage ignition wiring and fifth stage ignition cannot occur unless there is a pressure buildup in the fourth stage motor. Therefore, all stages are either destroyed or rendered non-propulsive.[14]

2. Sounding Rockets - Sounding rockets are used to fill the gap between the maximum altitude for balloons (about 30 miles) and the minimum altitude for satellites (about 100 miles). In addition, they are very useful to overlap the satellite space. Experiments flown on sounding rockets provide a variety of information, including high altitude wind shear and velocity measurements, density and temperature of particles in the upper atmosphere, properties and changes in the ionosphere, measurements of the brightness of stars and natural radiation surrounding the earth, characteristics of the ionization phenomena as space vehicles reenter the atmosphere and many other phenomena of earth's environment.[15]

Fifteen different launch vehicle systems are currently used by NASA to provide the performance requirements necessitated by various experiments with diverse weight and altitude requirements, with a launch rate of 30 to 35 launches each year.

Figures 11[1] and **12**[2] show the typical sounding rocket vehicles in the NASA inventory and their performance capabilities. It should be noted that these vehicles are not necessarily available for commercial use.

Approximately 2,500 NASA sounding rocket missions have been conducted since 1959 with an 86% mission success rate for that period, and a 96% mission success rate for over 142 missions in the last five years.[15,16]

a. Description - Currently, the Black Brant X, a Terrier, Black Brant, Nihka motor configuration provides the greatest performance of the sounding rockets. The Black Brant X can boost a 300 pound payload, launched at an 82 degree elevation angle, to a 453 nautical mile apogee altitude.[17] However, due to increasing requests from the scientific community, the National Aeronautics and Space Administration has developed a new sounding rocket vehicle system which, to date, has undergone one test flight. This system, named the Black Brant XII, offers increased performance over existing sounding rockets. The same payload and launch conditions on a Black Brant XII yields an 807 nm apogee altitude. The Black Brant XII is a four stage configuration composed of a Talos, Taurus, Black Brant, Nihka motor combination.[1]

b. Hazards - The hazards associated with sounding rockets are those associated with any solid rocket motors: they may generate intense heat, if ignited, become a missile or, if subjected to severe impact forces, explode. Generally, the most likely hazard is fire caused by burning debris from a case rupture. Explosions are normally limited to vehicles impacting the Earth at relatively high velocities (over 300 feet per second).

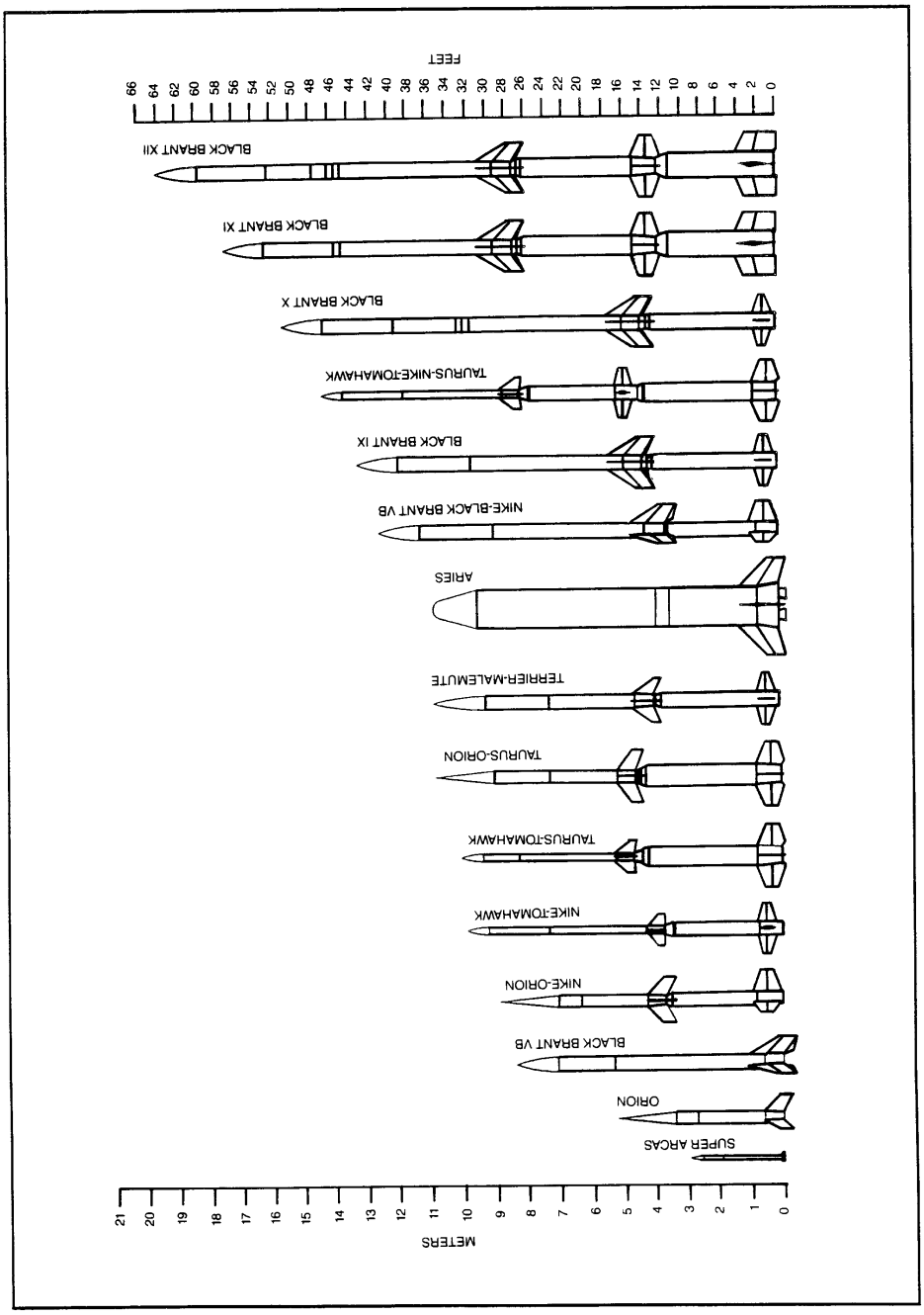

FIGURE 11. TYPICAL WFF SOUNDING ROCKET VEHICLES

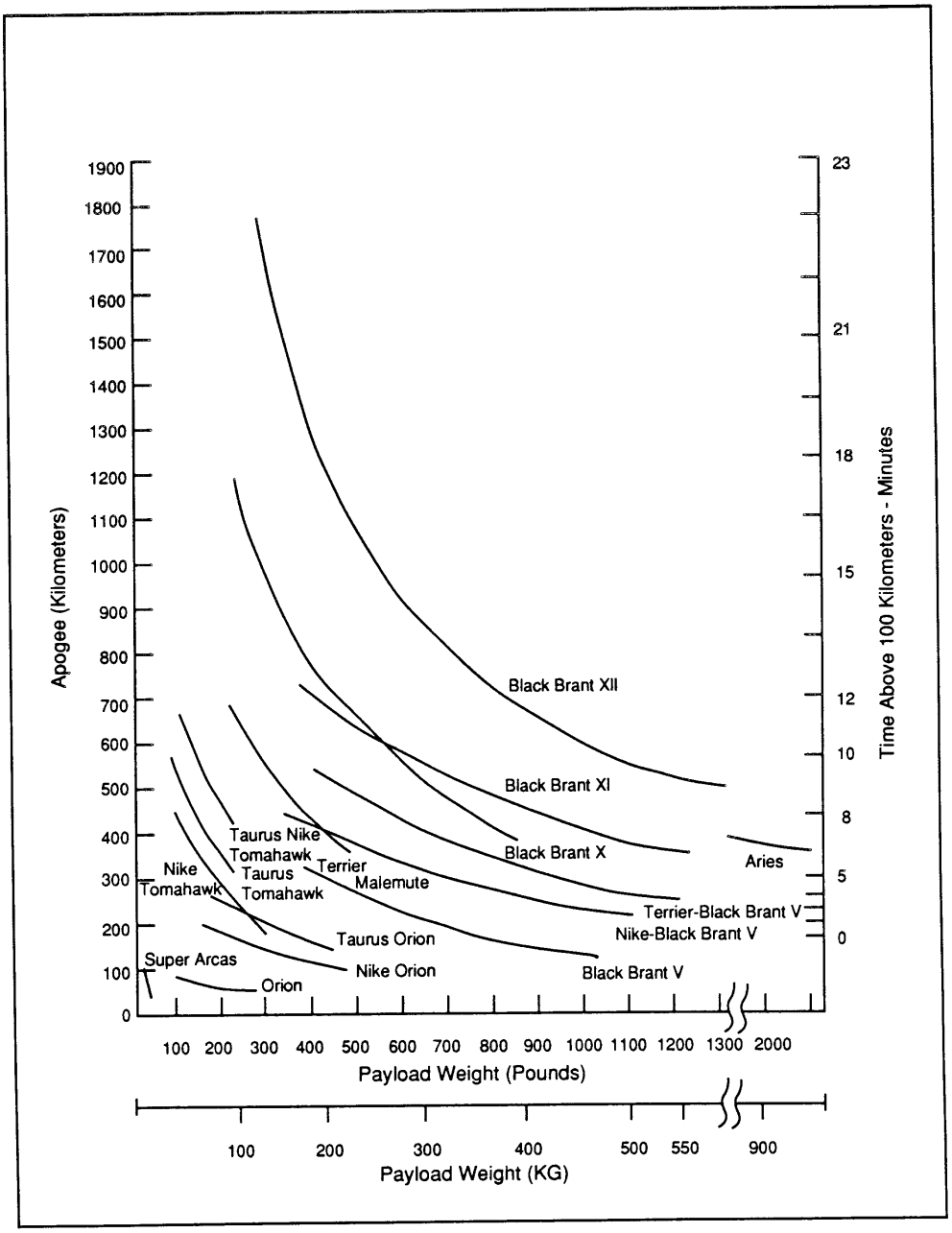

FIGURE 12. NASA SOUNDING ROCKET PERFORMANCE

c. Trajectories - Sounding rockets fly on azimuths of approximately 90^0-165^0 and elevation angles as follows:

- Vehicles flown for the first time - 80^0
- Proven flight-worthy vehicles - 84^0
- Vehicles with a flight termination system - $>84^0$

These trajectories carry scientific instruments to heights of from 40 to several hundred miles above the Earth's surface. Their effective lifetime is usually only a few minutes since they follow a trajectory back to Earth. The scientific data is collected and usually returned to Earth by a radio link. Parachutes are sometimes used to increase the experiment time and/or to recover the instruments for reuse.[2] See **Figure 13**[1] for a typical sounding rocket mission profile.

d. In-flight Events - Sounding rocket launch vehicles carry research payloads with scientific instruments to altitudes ranging from thirty miles to maximum altitudes of approximately 600 miles. The experiment time above the Earth's atmosphere ranges up to 15 minutes. Scientific data are collected and usually returned to Earth by telemetry links. **Table 5**[16] shows the event times for a Black Brant X sounding rocket. There are three types of payload recovery systems used by WFF at their various launch site locations: Land, Water and Air; however, land recovery is not used for vehicles launched at the Wallops Island Facility. Generally, the recovery systems contain two totally independent circuits for logic redundancy. Each circuit includes a "5g" timer, capacitor powerpack, safe/arm relay and a 20,000 feet baroswitch. In addition, for water recovery, the system contains flotation gear and location aids. For air recovery, the only onboard recovery equipment is a reinforced parachute which is snatched from the air by recovery aircraft.

TABLE 5. BLACK BRANT X NOMINAL SEQUENCE OF EVENTS

EVENT	TIME (SEC)	EVENT	TIME (SEC)
Terrier Ignition (First Stage)	T+0	Black Brant Separation	T+88.0
Terrier Burnout (First Stage)	T+4.4	Nihka Ignition (Third Stage)	T+93.0
Black Brant Ignition (Second Stage)	T+12.0	Nihka Burnout (Third Stage)	T+111.0
Black Brant Burnout (Second Stage)	T+44.4	Nose Cone Eject	T+115.0

e. Airborne FTS - Inherent safety for a sounding rocket is determined by probability estimates based on known system errors and a set of qualifying conditions as stated in paragraph **D.1.b.** and, in addition, the vehicle must be designed using state-of-the-art techniques that have been proven to be highly reliable by flight tests or otherwise proven flightworthy. If a sounding rocket cannot satisfy this set of conditions, a flight termination system that meets Range Safety requirements must be employed.

The requirements for using a flight termination system can be found in Section 6, Flight Safety of the GHB 1771.1.[18] Three types of flight termination systems are used for sounding rockets at the Wallops launch range: 1) fuel cut-off, 2) command destruct, and 3) ignition inhibit.

The fuel cut-off system closes valves which stops flow of the fuel and oxidizer to the thrust chamber, thereby terminating thrust. However, liquid propellant systems have not been flown from Wallops launch facility in the past 20 years.

Command destruct is the most widely used type of flight termination system at Wallops. In this system, an electroexplosive device in the vehicle is initiated when the destruct command is sent which ruptures the motor case, thus terminating thrust.

In the ignition inhibit type of flight termination system, the command to inhibit ignition is sent before the rocket motor ignites. This type of flight termination is used on vehicles that requires a flight termination system and when there is sufficient confidence that the vehicle will impact within safe limits. A gain in vehicle performance, due to less weight, is realized when using this system.

In all cases, flight termination is initiated from the ground (the control center) by the Range Safety Officer (RSO). This command is transmitted by one of the three command transmitters used by the Wallops range. Typical Sounding Rockets with flight termination systems that were flown from the Wallops range include the AEROBEE (in the 1960's), ATHENA (in the 1970's), BLACK BRANT V, BLACK BRANT X and BLACK BRANT XII (all still in the current inventory). Also, a new vehicle referred to as the TALOS/ARIES is planned to be launched from the Wallops range (FY90) and will be required to carry a flight termination system.

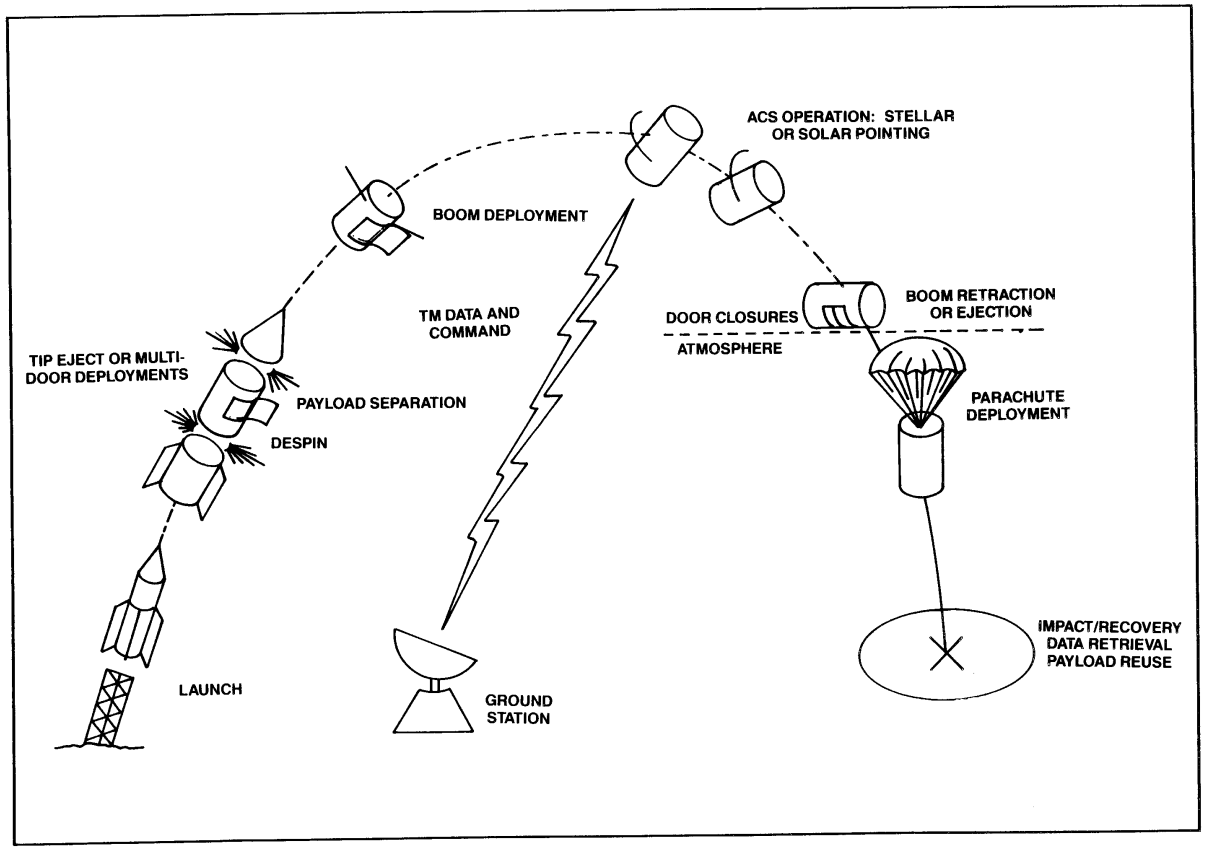

FIGURE 13. TYPICAL SOUNDING ROCKET MISSION PROFILE